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THE COMANDRA BLISTER RUST IN LODGEPOLE PINE

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The Comandra blister rust (Cronartium comandrae Pk.) is a fungus native to the United States that has been known on pines for nearly 80 years (1). Relatively little has been published on this rust since 1915 when Hedgcock and Long (13) compiled the information known at that time. Lodgepole pine (Pinus contorta Dougl.) has been regarded as only an occasional host for this pathogen; there are no published records of it causing damage of consequence to the tree. The present paper is concerned for the most part with the recent epidemic behavior of the parasite on lodgepole pine in the Intermountain Region.

RANGE OF THE RUST

Cronartium comandrae is of wide distribution. Its general range is from Quebec to Northwest Territory and British Columbia in Canada, and sparingly southward to northern Mississippi, New Mexico, and California in the U.S.A. (3). In western United States the fungus is present in all of the states from the Rocky Mountains to the Pacific Ocean.

HOSTS

The rust is a heteroecious fungus, i.e., it requires an alternate host for the completion of its life cycle (13, 16). The alternate host plants in the western states are two species of bastard toadflax, Comandra livida Richards and C. umbellata (L.) Nutt. The latter is by far the most common of the two.

Cronartium comandrae is confined to the hard pines and is known to attack about a dozen different species (3, 4). In western United States the rust has been reported on ponderosa pine (Pinus ponderosa Laws.), Arizona pine (P. ponderosa var. arizonica (Engelm.) Shaw), and lodgepole pine (13).

LIFE HISTORY

The fungus grows perennially in the living bark of pines; it develops annually on the toadflax where it may be found on both sides of the leaves and also on stems. Evidently infection directly from pine to pine cannot take place (13, 16).

In the Intermountain Region seasonal activity of the fungus usually starts in June with the production of whitish-colored spore sacs (aecia) on the pine cankers. The sacs soon break releasing great numbers of orange-colored spores (aeciospore) which are wind disseminated to the toadflax. About 10 days after infection of the latter (13), yellowish spots (uredia) about the size of a pinhead appear. In these spots spores (uredispores) are produced. These can infect other Comandra plants, but not pines. This is the repeating stage of the rust and serves to increase the disease on Comandra during the growing season.

About 15 days after the uredial stage appears on the Comandra plants brownish hairlike structures, called telia, begin to develop (13). Telia range in length up to nearly one-tenth inch and are composed of a mass of teliospores held together in a gelatinous matrix. In time, under favorable moisture conditions, the teliospores germinate and produce four tiny sporidia or basidiospores. These spores, which are airborne, are the only ones that can infect pines. This usually occurs in late summer or fall, thus completing the life cycle of the fungus. The aecia appear about 3 or 4 years after pine infection takes place (13).

CHARACTER OF ATTACK ON LODGEPOLE PINE

Cankers originate on needle-bearing twigs and stems, but it is not yet known if infection takes place through the needles or the young and tender bark. On branches, and also on trunks of young trees, a spindle-shaped swelling is characteristically formed. This swelling, or canker, is a thickening of the bark caused by a concentration of the fungus mycelium in the tissues. On trunks of older trees there usually is little or no swelling apparent and in some cases there is even a tendency toward constriction or atrophy. The infected bark becomes very roughened and abundant resin exudation usually occurs, the resin drying and accumulating for the most part over the cankered area. Aecia are seldom produced on the trunk cankers in large trees, probably because of the thick bark.

The fungus characteristically invades tree trunks via branches although it may also enter the main stem directly near the tip. Trunk cankers seldom exceed about $3\frac{1}{2}$ feet in length, even on the larger trees, before girdling occurs and that portion of the tree above the canker dies. If there are no live branches below the canker on the trunk the entire tree is killed. Branches, which still have reddish-colored needles attached after being killed by the pathogen, are termed "flags."

A heavily diseased lodgepole pine stands is characterized by branch flags and numerous dead and dying tops. The reddish-colored dead tops and the yellowish-colored dying ones may be so abundant that an entire stand is much off color in appearance. Many such stands have been noted in the Intermountain Region. They are easily seen, under good light conditions, for distances up to a mile or more either from the ground or from the air.

DAMAGE TO PINES

Cronartium comandrae has been reported causing considerable damage to ponderosa pine at various places within the range of that tree (4, 13, 14, 16). On some areas in northern California so many seedlings and saplings were killed that understocking resulted (16), and on one area there thousands of ponderosa pines have been killed (24).

Although lodgepole pine has been known for 50 years to be a host of the Comandra rust (13), no case of damage or heavy infection of this tree by the parasite has ever been reported. Furthermore, herbaria contain few specimens of the fungus on that pine species. It has been of more than ordinary interest, therefore, to find in recent years the rust common and destructive in stands of lodgepole pine over extensive areas in Idaho, Utah, and Wyoming.

No thorough or systematic survey has yet been made to appraise accurately the prevalence of this disease and the damage caused by it. However, heavily diseased lodgepole pine stands are now known to be present on six national forests in Region 4 and more lightly infected stands occur on two other forests. In one stand it was estimated that 98 percent of the trees were infected. Estimates made in other stands range between 50 percent and 85 percent. Many of these pine infection areas are from 1 to 3 square miles in size and larger ones are known to exist. All ages of trees are susceptible to the fungus, but most of the diseased stands known to date are composed largely of mature trees.

In all of the diseased stands there is ample evidence that the fungus is intensifying at a fairly rapid rate and that damage is increasing. Eventually these stands will be largely, if not entirely, destroyed by the parasite. No evidence has yet been found of past serious damage or losses in lodgepole pine stands caused by the rust. Garrett (10) who collected rusts in Utah for 34 years prior to 1937, did not report the parasite on lodgepole pine although it is now common in several counties there on that host. Cronartium comandrae was first noted on lodgepole pine in Wyoming in 1914 (13), yet the only known damage of consequence caused by the fungus in stands of this tree has occurred in relatively recent years.

EPIDEMIOLOGY

The character of the weather during the growing season influences infection of both hosts and also development of the rust. As a result of very favorable moisture conditions occurring in the Intermountain Region in 1952 and also in 1955, there was heavy infection of Comandra in both these years. On the other hand, the season of 1956 was so dry generally that very little rust appeared on that host. Not every year in which the rust is prevalent on toadflax, however, is the weather favorable for infection of pines. For example, even though toadflax was very heavily diseased in 1952, late summer and fall of that year was so dry little, if any, pine infection could have taken place.

All evidence indicates that the Comandra blister rust epidemic in this region is of relatively recent origin. In most of the heavily diseased lodgepole pine stands intensification of the rust started about 15 or 20 years ago, or possibly a little earlier in a few cases.

It is not definitely known what has caused this native fungus, of no previous economic importance in lodgepole pine, to become destructive recently. Moisture is needed for infection of both the pine and the alternate host plant. Unusually favorable climatic conditions therefore, particularly an abundance of rainy periods during the growing season and occurring over a number of years, could account for the present behavior of the pathogen. However, weather records do not support this possibility. Furthermore, if climatic conditions alone provided the answer there undoubtedly would have been moist years or periods in the past favorable for intensification and spread of the fungus.

Pine infection cannot occur without the alternate host being present in the vicinity of the pine stands (4, 13, 16). Accordingly, a logical explanation of the epidemic would be that there has been a marked increase, during recent years, in the abundance of toadflax. Current studies will help to determine if such an increase has occurred and if so, why.

The distance of spread of this rust from Comandra to lodgepole pine evidently is considerably greater than is commonly the case with the spread of white pine blister rust from ribes to pines. Heavy infection extending into lodgepole stands for distances of 1 to 2 miles or more is not uncommon.

ECOLOGY OF COMANDRA

No thorough study of the ecology of Comandra umbellata has been made. It has been reported as an intermediate plant, appearing in the succession when pioneer plants die out (15). Comandra is known to be parasitic on the roots of a large number of plants (5, 8, 11, 12, 19). It is a common associate of sagebrush on many areas in this region.

Comandra plants are herbaceous perennials and, according to Hedgcock and Long (13), spread primarily by means of seeds and secondarily by means of underground runners or rhizomes. The secondary method is the more common. The nutlike fruits are edible and are much liked by birds and rodents. It is possible that they may be carried by these animals to a considerable distance from the original place of growth, thus starting new plant colonies (13).

Comandra does not grow in stands of lodgepole pine, but rather is found on the surrounding open range lands. Its habitat has been recorded by various authors as: dry sandy slopes and banks (6), dry open ground (7), dry exposed plains and hillsides (9), dry rocky soils, which often have a low water content (12), gravelly soil (20), dry ground (21) and, dry ground and sandy soil (22). Many of the range lands in this region have been overgrazed and abused (2). When the habitat requirement is considered, it would appear that this changed range condition may have provided for an increase in the area suitable for growth and development of the plant. It may be of significance that every heavy lodgepole pine infection area so far known is in association with range lands that have had long and heavy use.

Comandra umbellata apparently has little, if any, forage value and is not included in the Range Plant Handbook (23). All evidence so far obtained indicates that the plant growing on open range lands is rarely utilized by grazing animals. The writer has encountered on such lands only one instance of sheep having fed on it. Shortly after a large band of these animals had been watched slowly feeding over an area on which the Comandra occurred commonly, an examination revealed that only an occasional plant had been eaten. No evidence of cattle utilizing the plant has been noted. Accordingly, it seems that toadflax is little disturbed in its normal reproductive processes by range animals.

RODENTS AND THE RUST

Lodgepole pine bark diseased with the Comandra rust evidently is very palatable to porcupines and other rodents because they commonly feed on it. This has been known for some time (4, 13, 14). The affected bark contains an abundance of fungus mycelium and presumably also an accumulation of starch. The animals in question apparently congregate more or less within the diseased stands where these food materials are available to them in abundance. Most of the bark removal occurs in late winter and early spring when other food materials are scarce. Similarly various rodents remove bark from cankers on white pines caused by the introduced white pine blister rust (*Cronartium ribicola* Fisch.) (17) and squirrels are believed to be the principal animals that feed on lodgepole pine bark diseased with the native rust *Peridermium stalactiforme* Arth. & Kern (18).

The writer has received a number of reports of severe porcupine damage in lodgepole pine. Inspection of such stands revealed that the foresters making the reports had not recognized that the presence of the Comandra rust fungus was a primary factor leading to the bark removal by the rodents. Lodgepole pine stands showing considerable evidence of porcupine damage should be looked upon with suspicion and closely examined for the presence of Cronartium comandrae.

CONTROL

Because the Comandra blister rust was regarded as of no particular economic importance in the past, no method of control of the pathogen has yet been developed. Control could be accomplished by the destruction of the alternate host.

Grubbing Comandra would prove not only expensive but also difficult because its underground rhizomes, which may attain 10 to 12 feet or more in length, are easily broken. Pieces left in the soil probably would start new plants in most cases.

A number of herbicides were experimentally tested during the past two seasons to determine whether Comandra could be destroyed by such materials. In no case was a satisfactory kill of the plant obtained. The experiments will be continued. In general, plants with rhizomes are difficult to kill with our present herbicides.

If the disease should be building up because of an increase in abundance of the alternate host, the relationship to range cover and range use may assume importance in its ultimate control. This phase of the problem is being studied.

There is evidence that low temperatures have an injurious effect on the Comandra rust in pines. In southern Idaho the net result of a cold spell was the almost complete elimination of the fungus from most of the trees in some 30-year-old ponderosa pine plantations (25).

Removal of diseased bark by rodents is a factor in reducing the quantity of aeciospores produced. On the other hand, the girdling done by the animals often hastens the killing of the cankered stems.

Where possible, cutting operations should be concentrated in heavily diseased stands. Removal of the infected individuals will serve not only as a sanitation measure, but also to salvage the trees before they die and deteriorate from decay and other causes.

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